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THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

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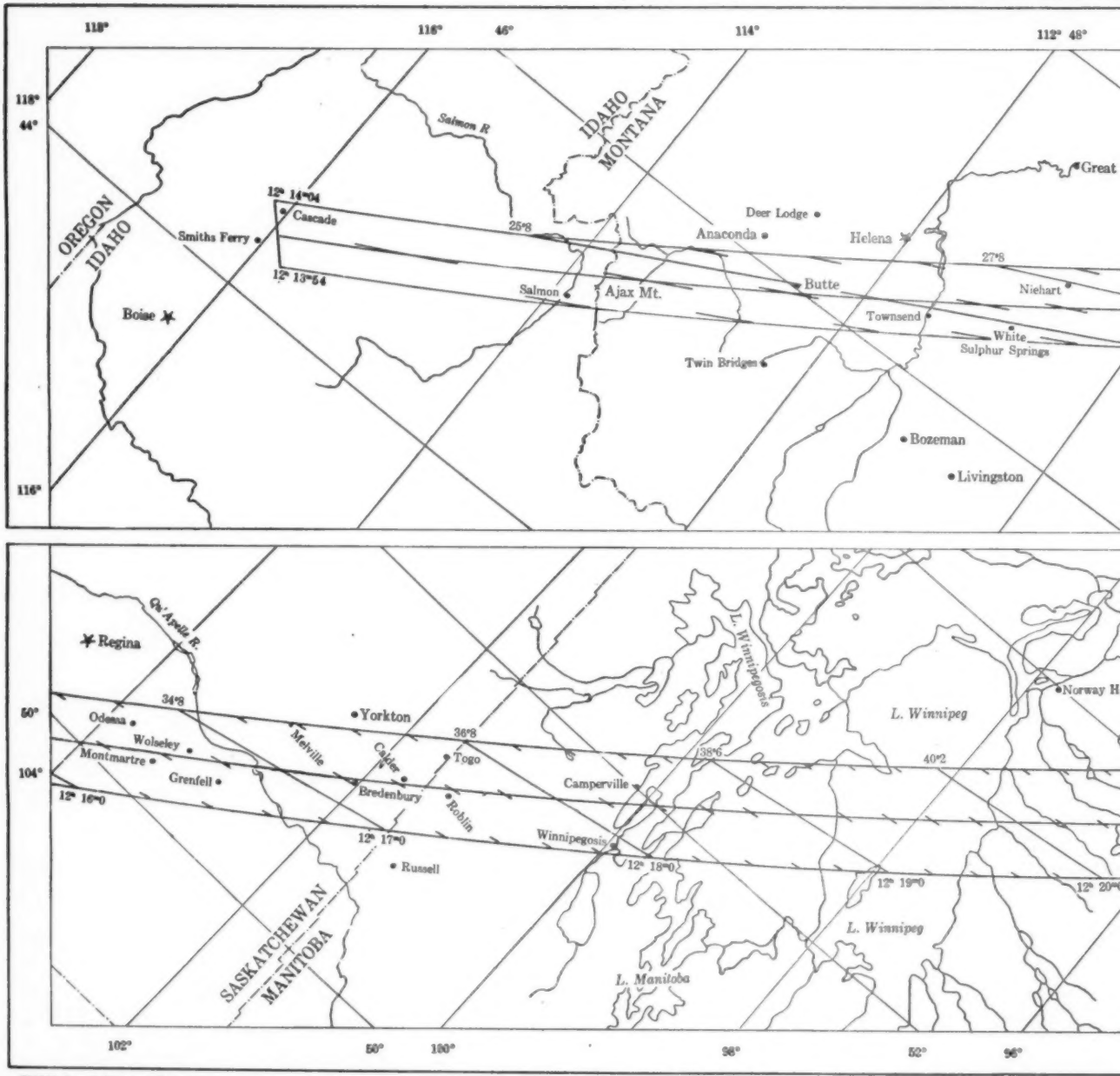

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Plate X—Journal of the Royal Astronomical Society of Canada, 194

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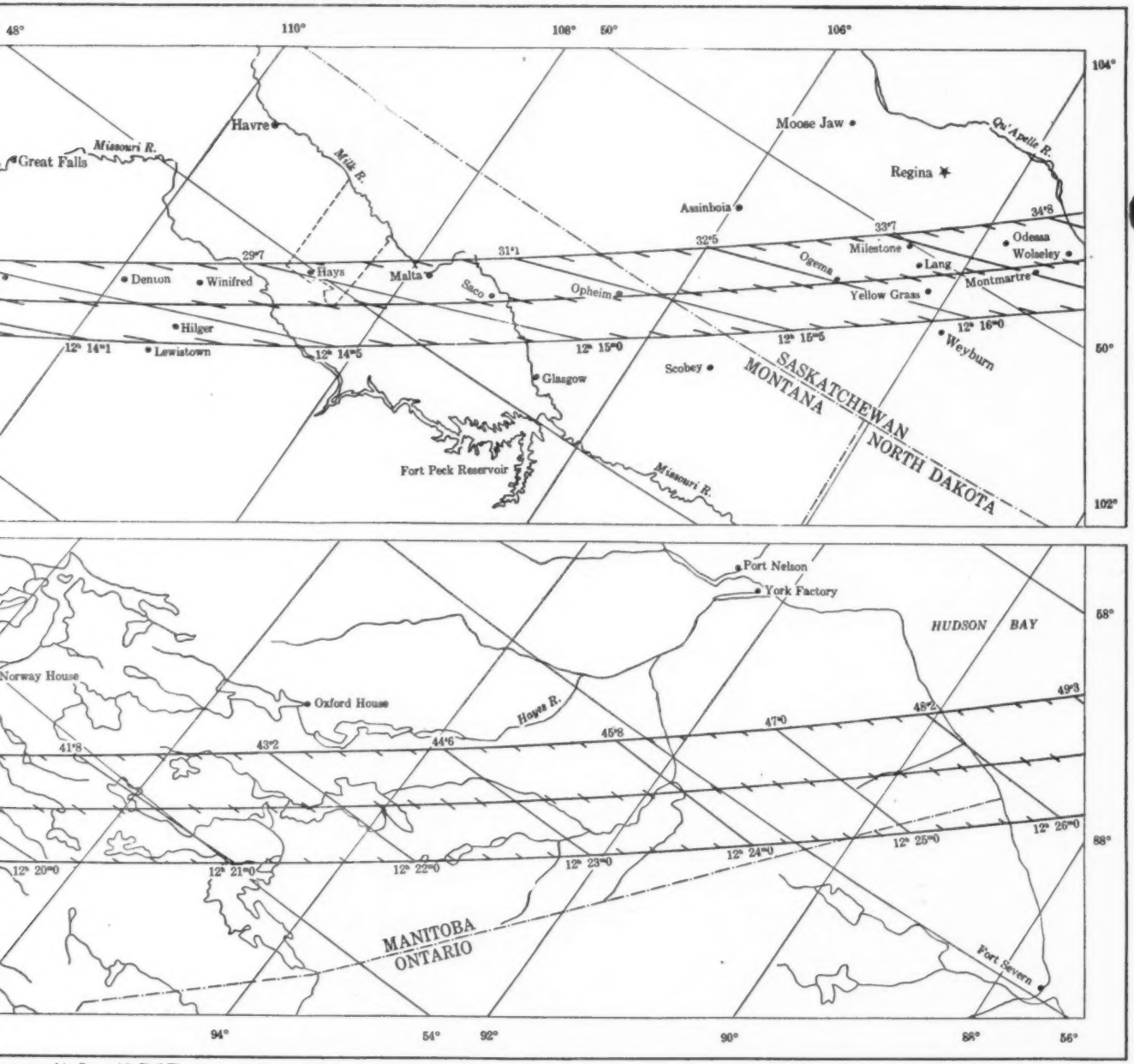

e expressed in Greenwich Civil Time

da, 1945. From the Supplement to the American Ephemeris for 1945

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VOL. XXXIX, No. 5 MAY-JUNE, 1945 WHOLE No. 344

THE TOTAL ECLIPSE OF 1945, JULY 9 IN WESTERN CANADA

(With folding Plate X)

By K. O. WRIGHT

AS total eclipses of the sun are rare and beautiful phenomena, great interest is always aroused upon the discovery that one may be observed from a particular locality. The rarity of eclipses is illustrated by the fact that the most recent total eclipse to be observed in Canada was in 1932, August 31 (over southwestern Quebec) and during the remainder of the twentieth century there will be only three more Canadian eclipses: 1954, June 30 (from Lake Superior to northern Quebec); 1963, July 20 (from the Yukon to southwestern Quebec); and 1979, February 26 (from southwestern Alberta to Hudson Bay.)

That eclipses are rare, but observable, arises from the approximate equality in the apparent size of the sun and moon as seen from the earth, and the intersection of the plane of the orbit of the earth and moon with that of the earth and sun (the ecliptic) at an angle of only five degrees. An eclipse of the sun can occur only at new moon when the moon is in the plane of the ecliptic, i.e. at a "node" in its orbit. As the position of the line of nodes is continually changing, new moon usually occurs when it is above or below the plane of the ecliptic, and there is no eclipse.

Three thousand years ago the Chaldeans discovered that there was order in successive eclipses: eclipses of approximately the same duration occur in the same latitudes at intervals of 18 years. Modern precise knowledge concerning the motions of the earth and moon permits an explanation of this observation. As new moon

and the position of the line of nodes[1] must occur together, an eclipse will repeat itself in the least common multiple of their periods, which is 6585 1/3 days, or 18 years, 10 1/3 days; this interval was called the Saros by the Chaldeans. The fact that this is not an integral number of days is reflected by the movement of the mid-point of the eclipse 120° west in longitude, caused by the rotation of the earth in one-third of a day. The observed phenomenon that the eclipse has approximately the same duration is because the point of nearest approach (perigee) of the moon, has a period which also very nearly divides into 6585 days.

There are, of course, several series of eclipses occurring in succession, each with a period equal to the Saros. The series to which this present eclipse belongs began as a partial eclipse near the north pole on 1639, January 4, but a total eclipse did not occur until 1891, June 6; the previous member crossed the British Isles on 1927, June 29, and the next in this series will be that of 1963, July 20, when the last half of the path, rather than the first half, will cross Canada.

The duration of any eclipse depends primarily on the relative distance of sun and moon from the earth. At its average distance (1 astronomical unit = 92,900,000 miles) the apparent diameter of the sun is 31′ 59″; the average distance of the moon is 239,000 miles and its apparent diameter is 31′ 05″. Thus it is seen that the diameter of the moon is usually less than that of the sun and even if other conditions are favourable, the sun will not be totally obscured but an annular eclipse will occur with a ring of the sun visible around the moon at mid-eclipse. Under the most favourable circumstances, when the sun is at its most distant point from the earth (aphelion) and the moon is at its closest (perigee), the diame-

[1]The various months, together with their definitions and periods are as follows:

Synodical (from new moon to new moon)	$29^d.530588$
Nodical (from node to node)	27.212220
Anomalistic (from perigee to perigee)	27.554550

The eclipse year (from node to node) = $346^d.620031$

223 synodical months	$= 6585^d.3211$
242 nodical months	= 6585.3572
239 anomalistic months	= 6585.5374
19 eclipse years	= 6585.7806

ters of the sun and moon are 31′ 32″ and 34′ 08″ respectively, and the eclipse may last 7½ minutes. It is interesting to note that if the diameter of the moon had been only one hundred and forty miles less, or if its minimum distance had been 18,000 miles farther from the earth, total eclipses of the sun would have been impossible.

The duration of an eclipse depends not only on the relative angular diameters of sun and moon, but also on the position of the moon's shadow on the earth. The moon advances in its orbit at at the rate of 2100 miles per hour, but the earth is rotating on its axis at the rate of 1040 miles per hour at the equator, in the same direction; therefore the speed of the moon's shadow as it passes an observer at that point is 1060 miles per hour. However at latitude 60°, the rotation of the earth is only 500 miles per hour, the moon's shadow moves at 1600 miles per hour, and the length of the eclipse is correspondingly shortened. These values are for the sun on the meridian (i.e. at noon), but near sunrise, the observer is not turned directly towards the sun and the projected velocity of the moon's shadow may be as high as 5000 miles per hour.

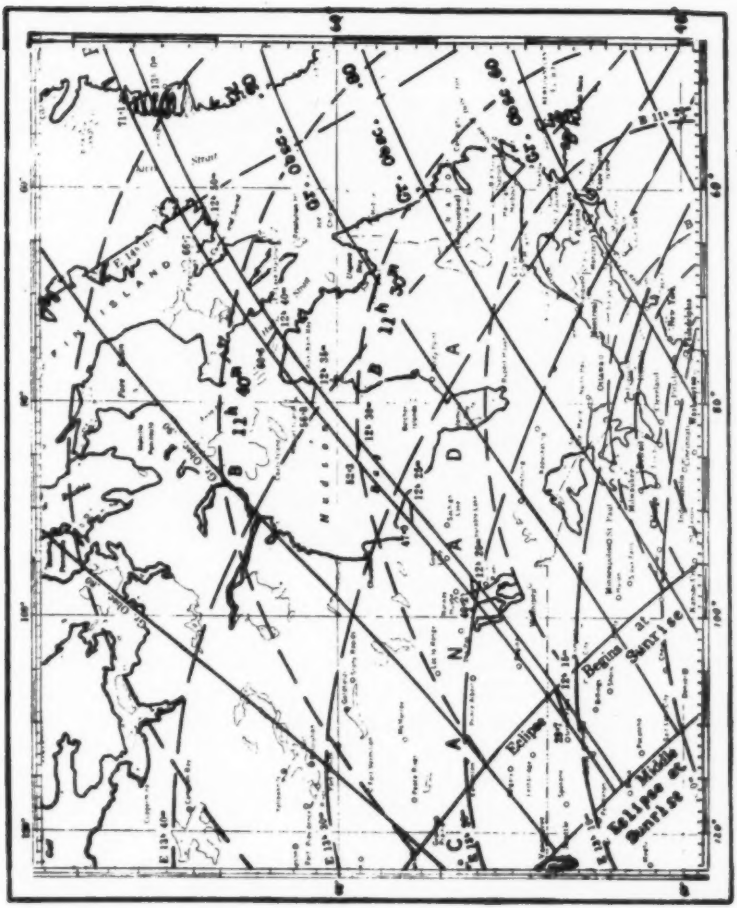
The above remarks apply to eclipses in general. Concerning the eclipse of 1945, July 9, preliminary information has been given in the *Observer's Handbook* for 1945 on page 56. Further detailed information has recently been published by the United States Naval Observatory in the "Supplement to the American Ephemeris for 1945", from which the maps accompanying this article have been adapted.

As shown in folding Plate X, the total eclipse begins near Smith's Ferry, Idaho, with the sun rising completely eclipsed. The path of totality is about twelve miles wide at this point, but gradually increases in width as it crosses the Canadian border below Assiniboia and passes just south of Regina and Yorkton, Saskatchewan; it crosses the centre of Lake Winnipeg and goes on to Hudson Bay below Port Nelson. The complete map for the path of totality shows that it crosses the Canadian mainland again at the northeastern tip of Hudson Bay, goes on to Greenland where the maximum length of totality (75.5 seconds) is reached at noon and then traverses northern Norway, Sweden and Russia, where it passes just north of Leningrad and Moscow, just south of Kuibyshev and ends at sunset close to Tashkent, which is north of Afghanistan.

The Plate shows the path of the eclipse over which most of the observations in this country will be made, and sufficient detail is given for anyone to determine just where the eclipse may be observed, its time and duration. The middle line shows where totality will be longest in a given region and this time is given at numerous points just above the upper line; the time of mid-eclipse is given below the lower line. These lines indicate the geographical limits of the total phase, and anyone within these boundaries should be able to see the corona if the sky is not obscured by clouds. As an example, consider a person in Ogema, just south of Regina: he is very close to the centre of the moon's shadow and from the diagram it is seen that the duration of totality will be 32.5 seconds and that it will occur at $12^h\ 16^m.0$, Greenwich Civil Time. As Saskatchewan is in the Mountain Time Zone, his Standard Time is 7 hours behind that of Greenwich, but his Daylight Saving Time is 6 hours slower; therefore his watch should read $6^h16^m.0$, M.D.S.T. However at Roblin, Manitoba, Central Time is used; there, totality will last 35.9 seconds and mid-eclipse will occur at $7^h17^m.6$, C.D.S.T.

Although it is strongly recommended that, wherever possible, members of the Society travel the necessary distance to see the total eclipse, most of us will not be able to do so. Therefore Figure 1 has been included to show the partial phases of the eclipse for almost all of Canada. This region will lie in the penumbra, and only a portion of the sun's disc will be obscured by the moon. At the western side of the map, the solid line passing through Vancouver shows where the maximum obscuration occurs at sunrise. Farther east, below Grande Prairie, Alberta, the moon will begin to pass over the sun just after sunrise. The dotted lines show the times of beginning (B) and ending (E) of the eclipse at other points For example, at Ottawa, the eclipse will begin at 7^h11^m E.D.S.T. (11^h11^m G.C.T.) and will end at 9^h14^m E.D.S.T. (13^h14^m G.C.T.). The lines parallel to the path of totality indicate the obscuration of the solar disc at a given place; however this value gives the greatest diameter of the sun which is covered, and not the greatest area. At Edmonton, about 89% of the diameter will be covered at maximum which will occur about 6^h26^m M.D.S.T. (12^h26^m G.C.T.).

For those who can observe only the partial phases of the eclipse,


Begins Sunrise
Eclipse
Middle Eclipse at Sunrise
Ends Sunrise
Eclipse
Gr.
Gr.
Gr.

the event is well worth an early rising—especially as the major portion of the disc is covered from all points in Canada. With a pair of dark glasses, or a piece of smoked glass held in front of the eyes to cut down the glare of the sun, it is most interesting to see a section "bitten" out of the sun—very small at first, just after first contact, which increases to a maximum and then decreases in size until the moon has passed the sun two hours later. If the eclipse is viewed within a few hundred miles of totality, there may be a slight darkening of the sky, and the light shining between the leaves on the trees will form clearly-defined crescents, the images of the partly-covered sun, instead of the usual circles.

In the path of totality, the phenomenon is much more striking. About ten minutes before totality, the sky becomes darker and the light from the edge of the sun is so different that eerie effects are produced on the landscape, the temperature falls and birds frequently go to roost. A minute or so before totality, the shadow bands, which are alternating bands of light and shadow, usually move across the ground. They are probably caused by currents of air which have different densities, as they move above the earth, but further observations, both before and after eclipses are desired. Just before the shadow of the moon completely obscures the sun, the edge of the sun is broken up by irregularities in the moon's surface and Baily's beads—bright patches of the sun shining through the lunar valleys—are seen.

Totality begins with the disappearance of the thin solar crescent at the time of second contact, and may begin before the last of Baily's beads have disappeared. Observations of second contact are particularly valuable to check the accuracy of the astronomical tables which are used in the calculation of eclipses. Accurate timing is essential, however, and the clock should be checked against *accurate* radio time signals for several days both before and after the eclipse to determine its rate. If available, a stop watch started at the instant of second contact, and compared with the clock immediately after totality, should be used. If such observations, together with the exact locality of the observer, are forwarded to the writer, they will be sent on to the proper authorities.

At totality, the corona, chromosphere and prominences and

the brighter stars and nearby planets become visible. Saturn, which will be only 2½ degrees above the sun, will be conspicuous, and Venus and Mars will be near the meridian. As the sun is in Gemini, Castor and Pollux may be low on the horizon, but Aldebaran, Capella, and the stars of Orion should be clearly visible.

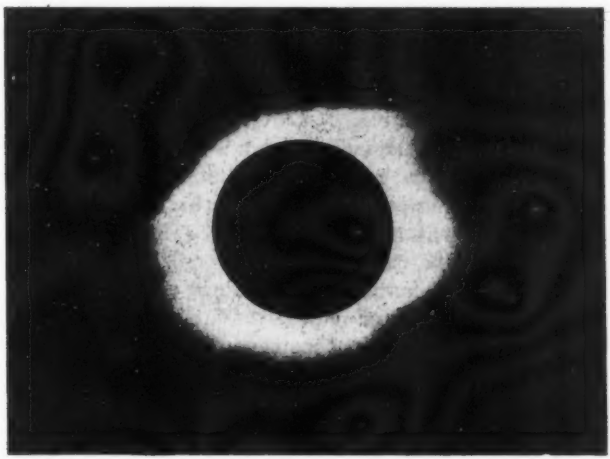


Fig. 2. The Total Eclipse of the Sun of September 10, 1923, Photographed by the Swathmore expedition to Yerbanis, Mexico.

Of the phenomena visible during totality, the corona is the most remarkable and unusual. The inner corona appears as a pale pearly-white ring extending about half the diameter of the moon; it seems brilliant, but is actually only about half as bright as the full moon. As the eyes become accustomed to the phenomena, the faint extensions of the outer corona and the coronal streamers, which often extend a million miles into space, can be seen. The form of the corona depends to a great extent on the sunspot cycle of 11.1 years. At sunspot maximum the streamers may extend equally in all directions. At sunspot minimum, as at the time of the present eclipse, the equatorial rays predominate, but the polar rays, while shorter, are more sharply defined. The corona shown in Figure 2

was taken by the Swarthmore expedition to Yerbanis, Mexico on 1923, September 10, and gives some idea of what may be observed this year.

In addition to the whitish corona, "rosy" prominences due to the hydrogen Hα line may frequently be seen close to the moon's limb. At some eclipses they have been the most interesting feature. One of the best descriptions of the phenomena seen at a solar eclipse was given by Baily, an amateur who was able to follow astronomy as a hobby, and the discoverer of the "beads". He observed an eclipse at Pavia, Italy, in 1842[2] and reported:[3] "The beads were distinctly visible . . . . At the [next] instant the dark body of the moon was suddenly surrounded by a corona, a kind of bright glory . . . . I had anticipated a luminous circle round the moon during the time of total obscurity but did not expect to witness so magnificent an exhibition . . . . The breadth of the corona appeared to be nearly half the moon's diameter. It had the appearance of brilliant rays. Its colour was quite white, not pearly colour, nor yellow or red . . . . But the most remarkable circumstance attending this phenomenon was the appearance of three large protuberances apparently emanating from the circumference of the moon but definitely forming a portion of the corona. All of these projections were of the same roseate cast of colour and were very distinct from the brilliant white light that formed the corona."

At the end of the eclipse, the sky becomes brighter again, but the inner corona may remain visible for half a minute. The first speck of sun appears much larger than it really is, due to irradiation, and that, combined with the inner coronal ring, presents the "diamond ring" which has frequently been described.

Professional astronomers are fully occupied with their duties during an eclipse. These include the determination of the times of second and third contacts; photography of partial and total phases; spectroscopic observation of the reversing layer, chromosphere and corona; photometric observations for the measurement of the intensity and polarization of the corona; and studies of the effects

[2]The sunspot cycle was also at a minimum in 1842 and corona which he observed was probably similar to that shown in Figure 2.

[3]Mem. R.A.S., vol. 15, p. 4, 1846; Mitchell, Eclipses of the Sun, 1923, p. 132.

of the eclipse on radio reception. Therefore it remains for the amateur observers to fully appreciate the beauty of the eclipse. However, in addition to the determination of time of first and second contacts, amateurs may profitably take direct and motion pictures of the eclipse, preferably with colour film. If a small telescope is available, larger scale photographs may be obtained by mounting the camera on the telescope and removing camera lens and eyepiece.

As the sun will be only 8½ degrees above the horizon when the shadow of the moon crosses the Canadian border, and as the altitude increases to 42 degrees in Greenland, it might seem that it would be better to view the eclipse as far north as possible. However, A. J. Connor[4] has discussed the probabilities of clear skies for the eclipse and has come to the conclusion that the chances are 3 in 5 for a clear sky in Saskatchewan, but decrease steadily to only 3 in 10 in the region of Hudson Bay. As transportation is difficult north of Lake Winnipeg, it would appear that most amateur observers in Canada would be well advised to observe the eclipse between the United States border and Lake Winnipeg. Let us hope that good weather will favour them, and that they may fully observe this truly inspiring phenomenon.

Dominion Astrophysical Observatory,
Victoria, B.C.,
1945, April 12.

[4]Journal R.A.S.C., vol. 39, p. 42, 1945, February.

PROGRAMME OF OBSERVATIONS DURING A TOTAL ECLIPSE OF THE SUN

(Although many of the points listed below have been mentioned already, the following list is so complete that it seems desirable to present it in full. It has been adapted from a sheet prepared by Prof. W. C. Rufus, Director of the University of Michigan Observatories, for the Detroit Astronomical Society. It was sent to the Editor by Mr. C. B. Hallam, of the Windsor Centre of the R.A.S.C.)

First Contact

Observe the time; and the angular position of the moon on the sun's disc.

Note the progress of the partial phase by exposures with a fixed camera at five-minute intervals.

Can any part of the moon be seen beyond the sun's disc? Contrast the sharp, jagged limb of the moon with the smooth outline of the sun.

If any sun-spots are visible, contrast the dark colour of the moon and spot as the moon crosses over it. Note the apparent change in colour of the spot.

Observe the shape of the sun's image under trees, or projected through a pin-hole onto a white screen.

Note the change in colour of the grass, trees, landscape and countenances of other observers.

Does the temperature change appreciably?

Is there any effect on radio reception?

How do animals and birds react to the phenomenon?

When do the stars and planets appear?

Near Totality

Note the swift approach of the dark shadow from the southwest.

Observe the shadow bands on the ground or on a wall. (A large white sheet may be spread out to observe them more accurately.) Note their distance apart, the direction of motion, and their velocity.

As the crescent of the sun decreases in size, note any pulsations or unsteadiness of the image, and any colour effects of the tips of the crescent.

Note when and how many Baily's Beads can be seen.

Second Contact

Note the time (or start the stop watch) when the last of the crescent disappears.

On which side does the corona first appear?

Observe the colour and form of the chromosphere and prominences.

For the corona, note the inner detail and colour; farther out, note the shape, polar rays, interlacing filaments and the length of the streamers. Note its relation to spots and prominences, if any.

Estimate the total brightness of the eclipsed sun.

What planets can be seen? What magnitude stars can be seen?

Concerning terrestrial conditions, note any change in temperature, and change in radio reception.

How dark does the sky become? How far away can objects be seen? Are any shadows visible? What colours can be detected?

Third Contact

End of totality. Note the time when the first crescent appears.

Phenomena of the partial phase occur in the reverse order.

Fourth Contact

End of the partial phase. Note the time when the last portion of the moon disappears from the sun's disc.

ANNUAL MEETING OF THE A.A.V.S.O.

By David W. Rosebrugh

THE Thirty-third Annual Meeting of the American Association of Variable Star Observers was held at Harvard Observatory, Cambridge, Massachusetts, on October 6 and 7, 1944. Some 65 members from nearby states gathered to discuss technical problems.

Mr. Leon Campbell's thirteenth annual report as Recorder showed that 32,767 observations were made by Association members during the year. Six Canadians submitted 2,381 of these observations. M. Paul H. Nadeau was the high Canadian observer with 1,337 observations to his credit. It is anticipated that the 1,000,000 observation mark will be reached by the 35th anniversary of the founding of the A.A.V.S.O. which occurs in 1946.

The Auroral Committee, which works in conjunction with the National Geographic-Cornell University auroral program, was reappointed for a third term of three years. Mr. Bertram J. Topham of Toronto, first Chant Medalist, who recently was severely burned by electricity, is a member of this committee. The report of the committee indicated that immediately after the war various electronic devices will be put into service at Ithaca, N.Y., and Milwaukee, Wisconsin, to measure electrical, magnetic and optical phenomena associated with aurorae. The importance to radio engineers of information upon the aurora was emphasized by Captain Lewis J. Boss, A.A.V.S.O. Councillor, who is in charge of radio communication for the Rhode Island police.

Prof. Alice H. Farnsworth presented the Occultation Committee report and commented upon the informative series of articles on this subject by Mr. H. Boyd Brydon, which are appearing in this Journal.

A Solar Study Group was formed under the leadership of Mr. Neal J. Heines, Paterson, N.J. Mr. Heines explained that more continuous data upon sunspottedness are required than are at present being obtained and outlined the visual methods to be followed in securing them. Mr. Charles Federer, Jr., commented during the discussion that the last sunspot cycle is considered to have ended in 1944.3, though the first spots of the present new cycle appeared as

long as two years ago. The next maximum is predicted for 1948 though this is subject to question.

A committee of the members of the Association, headed by Mr. Eugene H. Jones, Goffstown, N.H., presented the eighth Merit Award of the Association to Mr. Leon Campbell, Harvard Observatory, Recorder and Pickering Memorial Astronomer, who, by his devotion to the work of the Association, has made outstanding contributions to the field of variable star astronomy. The framed Award, which was designed and executed by Mr. Fred E. Jones, Allston, Massachusetts, won the admiration of those present.

Dr. Sergei Gaposchkin of the Harvard staff spoke upon "Elusive Stellar Radii." Our familiarity with the sun has given us the impression that stars have sharp-edged discs, but it now appears probable that some stars have fuzzy edges. In certain cases it has been found that the photographic light curves of eclipsing variables are of different shape from the visual light curves. The visual light curves decline gradually to a minimum and rise correspondingly slowly to maximum, while the photographic light curves show a shorter period for the entire minimum from the start of the decline to the end of the rise and the decline and rise are much more abrupt. This indicates that photographically the star discs are of smaller diameter than they are visually. Presumably the differences in size are caused by fuzzy atmospheres surrounding the denser cores of the stars. This recent discovery enhances the importance of visual observations of eclipsing variables. Turning to the subject of long period variables, Dr. Gaposchkin indicated that it is probable that these stars have fuzzy atmospheres surrounding them, and visual light curves of such stars differ somewhat in shape from the photographic light curves. The difference between the two curves is probably caused by the fact that the eye records the variations in brightness of the outer surface of the stellar atmosphere while the camera records the variations in the brightness of the inner, hotter and bluer core. Analysis of the differences between the two types of light curve may make it possible to draw some conclusions as to the fuzz surrounding the star. As Dr. Gaposchkin remarked "astronomers are now becoming fussy about the fuzz," and again he emphasized the renewed importance of visual light curves of variable stars.

Mr. D. W. Rosebrugh described the uses to which roof prisms may be put by amateurs when they become available after the war. A "reject" roof prism secured from a war plant was mounted in a metal cell like an ordinary zenith prism. A second finder was installed on his Newtonian reflector with the eyepice of the finder adjacent to the Newtonian eyepiece of the reflector. When the roof prism is inserted in the eyepiece end of the finder the rays of light are brought out at right angles to the tube of the finder, and parallel to the eyepiece of the Newtonian reflector, so that one can look through either the finder or the reflector by moving one's eye a short distance sideways to the main reflector tube. This result could of course be achieved by the ordinary zenith prism, but when a zenith prism is used in a refractor finder the field of view is reversed, as in a mirror, so that the field seen in the finder is reversed in one coordinate, compared with the field seen in the Newtonian, which like the field of view of a refractor is inverted because two reflections take place, one from the mirror and the second from the diagonal.

With the roof prism, however, the field of view is not reversed and it is therefore much more usable than the image obtained with an ordinary zenith prism, which is nearly unusable. The field of view of the roof prism is, however, not inverted, but erect. It would be handier to use the finder on the reflector if its field were inverted, but in practice all one has to do is to rotate the variable star chart 180 degrees when looking into the finder eyepiece instead of into the eyepiece of the Newtonian reflector. If an "erecting lens" were placed in the optical train of the finder it would of course be possible to reinvert the field of the finder, equipped with the roof prism, so that the field of view of the finder and the reflector would be identical (except for difference in size) but in practice this has not been found necessary.

This finder with a roof prism when mounted on a Newtonian reflector has been found to be more convenient to use than finders of any other type, even the conventional finders mounted on refractors.

Other uses for roof prisms upon which Mr. Rosebrugh hopes to report more fully at a later date are (1) to replace the ordinary zenith prism in a celestial refractor for looking at variable star fields, (2) for use in an ordinary celestial refractor to make it a terrestrial tele-

scope; when used thus the telescope will be pointed horizontally at the distant object and the observer will look vertically downwards into the telescope eyepiece and a vew of the landscape will be seen, erect and correctly oriented, and (3) for use in a Newtonian reflector to render it a terrestrial telescope. When used thus the roof prism in its cell should be inserted in the rack and pinion focussing tailpiece of the reflector, an eyepiece should be inserted in the roof prism holder and the observer should face in the same direction that the Newtonian is pointed, and look into the eyepiece. Mr. Rosebrugh cautioned his hearers that if they were working with roof prisms they should use care not to chip the "ridge of the roof", which is a sharp edge which cannot be bevelled, for reflection takes place right up to the angle of the roof.

Mr. David Simon, Montreal, P.Q., Mr. L. W. Carrigan, New Glasgow, N.S., and sixteen others were admitted to membership in the Association. Mr. Roy A. Seely, New York City, was elected President, Dr. Charles H. Smiley, Ladd Observatory, Brown University, Providence, R.I., was elected First Vice-President, Dr. Marjorie Williams, Smith College Observatory, Northampton, Mass., Second Vice-President; and Mr. Leon Campbell, Harvard Observatory, Mr. Percy W. Witherell, Jamaica Plain, Mass., and Mr. D. W. Rosebrugh, Waterbury, Connecticut, were reelected Recorder, Treasurer and Secretary respectively.

Dr. James W. Baker, of the Harvard staff, explained the new type of photographic reflecting telescopes developed by M. Matsukov, Director of State Institute of Optics, U.S.S.R. The newspaper account of the advantages of this telescope have been somewhat misleading. In principle it is similar to the Schmidt camera in which there is a spherical reflecting mirror in front of which is placed a correcting lens. In the Schmidt camera the correcting lens is a compound curve, so that in portions the lens is positive and in others it is negative, though it is of very weak curvature so that the camera is achromatic. The Matsukov telescope substitutes a concave meniscus for the correcting lens of the Schmidt. This is easier to figure than a Schmidt because the surfaces are all spherical, but theoretically it does not give as perfect definition as the Schmidt correcting lens. The probable practical limit of the Matsukov camera is F1.5 while a Schmidt can be made as fast as F0.59.

Dr. Shapley gave his usual talk upon "Astronomical Highlights of the Year." Among these were: (i) Comet Oterma 1943a which is on the borderline between a comet and an asteroid. Physically it is a comet, but its orbit lies between that of Mars and Jupiter. (ii) The discovery of methane and ammonia in the atmosphere of Titan by Dr. Kuiper. (iii) The analysis of the orbits of Mercury and the earth by Dr. Clemence of the U.S. Naval Observatory, which showed an advance in the perihelion of Mercury of 42.9 seconds and in the perihelion of the earth by 3.8 seconds per year. The advance in the perihelion of Mercury is well known but this is the first time that an advance in the perihelion of the earth, in accordance with the Einstein theory has been demonstrated. (iv) The discovery of solar spicules by Dr. Roberts of the Climax, Arizona, Observatory of Harvard. These occur in the north and south polar regions, formerly considered inactive. Spicules look like welts on the sun, 5000 miles in diameter and 2000 miles high. These swell and eject a spike, inclined to the surface of the sun, and disappear after a life of 3 or 4 minutes. (v) Data on the sun's five nearest neighbors indicate that all are double or multiple, which possibly indicates that a larger per cent of stars are binaries than had previously been supposed. (vi) The discovery by Van Biesbroeck of a faint red companion of BD+4 degrees 4048 which is only 7 to 10 times brighter than the light Jupiter reflects. This object is 3 magnitudes absolute fainter than any star previously discovered. (vii) The discovery of "shell" stars which are stars surrounded by a hollow spherical atmosphere far above the surface of the star. (viii) The correction of the estimated distances of 30 globular clusters to allow for absorption. For instance, the distance of M13 in Hercules is now considered as 31,000 l.y. instead of 33,000 l.y. Dr. Helen S. Hogg, David Dunlap Observatory, provided the photometric work for this reestimate of this star cluster. (ix) The resolution of the nucleus of the Andromeda nebula into stars by photographic means as contrasted with spectroscopic means.

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THE 1941-2 APPARITION OF MARS

(Concluded from April number)

By WALTER H. HAAS

CONCERNING CHANGES ON MARS

Seasonal changes have been described in detail by some past observers.[7,8] A study of the description above, with reference to Table II, will show that such changes were again observed. The summer darkening of southern features was verified, Sabaeus becoming darker at ☉ 240°, Pandorae near ☉ 270°, Solis and Nectar near ☉ 275°, the edges of Hellas near ☉ 280°, Chronium near ☉ 285°, and Erythreum and Aurorae near ☉ 315°. The progressive darkening of Margaritifer from ☉ 235° to ☉ 345° and the increased duskiness of Atlantis and Hesperia as compared to their 1939 appearance at an earlier season[4] illustrate the same phenomenon. A corresponding winter seasonal lightening of northern features can also be exemplified. Acidalium grew fainter near ☉ 265°, and canals north of Sabaeus lightened from ☉ 220° to ☉ 290°; moreover, some northern features were vaguer than in 1939 at an earlier season. After ☉ 0° it was spring in the northern hemisphere and autumn in the southern. Though southern marks may now have lightened, evidence is inconclusive, perhaps because the planet had become remote (Table II). Unmistakable darkenings of northern features were observed. Nuba grew progressively more intense from ☉ 245° to ☉ 20°, as did Acidalium from ☉ 320° to ☉ 20°; canals north of Sabaeus grew stronger near ☉ 330°, and the Amazonis shading was darker after ☉ 350°.

Some exceptions were found to the pattern of seasonal changes just described. The *southern* Mare Australe grew lighter, at least in part, from ☉ 180° to ☉ 270°. The *northern* Nepenthes was much darker after ☉ 280°. Ambrosia canal was fainter than in 1939 when viewed earlier in the *southern* spring.[4] Some other changes do not appear to be seasonal at all; examples are the appearance of the oval bright bay near λ 190° and the conspicuousness of Coloe and Nilosyrtis between ☉ 240° and ☉ 270°. Some alterations observed occurred so rapidly and in a manner apparently so irregular that one is obliged to impute them to a variable

obscuring action of the Martian atmosphere. The reader can find many examples in the description above. A few such are the extreme vagueness of Solis and Nectar from August 20 to 24, the September fading of Tartarus and the blunting of Syrtis Major in June. The Martian atmosphere may also have been responsible for some of the other kinds of changes.

The South Cap

The variations in size of the south cap are shown on figure 7, the angular diameter being plotted against ⊙. The visual curve is based on measures of 236 *original* drawings by seven observers between ⊙ 119° and ⊙ 59°. Such measures encounter several sources of error. The phase, D ⊕, and a possible eccentricity of

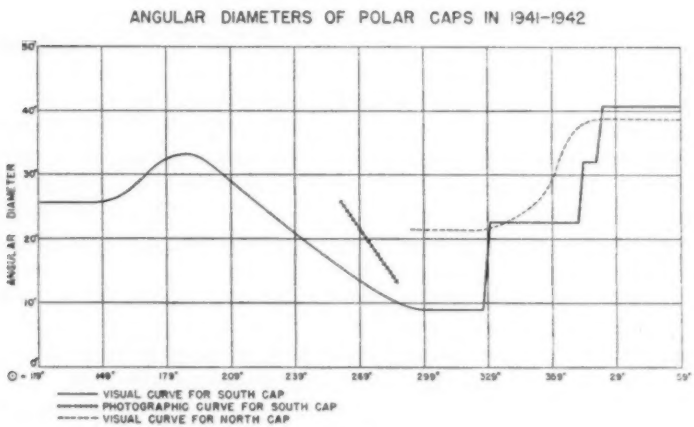

Fig. 7

the cap with regard to the geographic pole all affect the observed size of the cap, which may also vary falsely with changes in the seeing and the transparency. Moreover, different observers may be subject to systematic errors relative to each other in their results. These various matters were investigated, and suitable corrections were applied when they were found necessary. The photographic curve in the figure is based upon measures by Vaughn

of photographs by Wilson on 14 dates between ⊙ 261° and ⊙ 289°. It will be noted that the visual and photographic curves differ greatly in this interval. I think that the smaller diameters obtained from drawings should be preferred, partly because irradiation must cause spurious enlargements of the cap on both drawings and photographs and partly because I frequently perceived with good seeing that drawings usually showed the cap too large. At least one past observer has reported a similar difference between photographs and drawings.[9]

The phenomena presented by the cap are best interpreted by assuming the existence of both a surface-cap and an atmospheric cap.

Three observations between ⊙ 119° and ⊙ 126° showed a whitish south limb on the tiny disc. At ⊙ 151° there was a white and distinctly outlined, but only moderately bright, cap; and this aspect was still present at ⊙ 169°. Presumably a cloud-cap overlay the polar region. By ⊙ 185° on April 25 a distinct change in character had occurred. The cap was now large, pure white, and brilliant. As in 1939, the maximum size was apparently attained after the vernal equinox of the southern hemisphere at ⊙ 180° (figure 7).[4] Melting began near ⊙ 195°.

A dark south polar band borders the cap when it is shrinking. This melt-band was *suspected* as early as ⊙ 168° but was still not completely certainly visible at ⊙ 185°. It rapidly grew stronger and was conspicuous by ⊙ 194°. Perhaps its presence indicated that melting was then already in progress.

Near ⊙ 200° the cap underwent a temporary obscuration by Martian cloud or mist. On May 17 H. Johnson and R. Johnson found the cap brilliant and well-defined. On May 22 R. Johnson remarked that the cap was much smaller and duller than on May 17 and that its edge had become indistinct, and on May 26 H. Johnson confirmed the altered aspect. By May 29 the initial size and brightness had been restored.

The rifts seen in the south cap between ⊙ 196° and ⊙ 208° in 1939[4] were not confirmed in 1941, perhaps because the planet was still remote at the proper season (Table II). There is no evidence that the fastest melt came between ⊙ 210° and ⊙ 225°[4] at the

later apparition. However, the visual curve shows that the rate of melting grew slower as the season advanced.

At ⊙ 215° a sharply outlined and brilliantly white cap was surrounded by an intense melt-band by now darker than most, perhaps all, of the *maria*. The cap preserved this general aspect for many months, though with some variations in brightness besides the steady decrease in size. For example, there was a period of comparative dimness from June 26 to 30, ⊙ near 223°. Moreover, on July 22, 24 and 25, ⊙ = 238° to 240°, I observed a very brilliant spot in the following part of the cap when the central meridian was 354°. This spot was not clearly seen between July 18 and 21 under better conditions than on the later dates and was presumably less well-defined than it later became. A remnant of this brilliant spot may have existed into August and even September and October. During July and August the south polar band was regularly seen and showed some variations in width and darkness in different longitudes. After ⊙ 250° it grew progressively less prominent. By ⊙ 280° it was faint, and it apparently disappeared entirely after ⊙ 311°.

The cap was first seen to lie entirely on the disc at ⊙ 257°; but it was not until about ⊙ 285° that this aspect was regularly visible, such were the effects of irradiation and foreshortening. The cap did not become dimmer after ⊙ 295°, as it had in 1939,[4] but remained brilliant. Melting ceased at *about* ⊙ 295°, and the diameter was now stationary for a time at a minimum value of about nine degrees. The cap was last seen tiny and brilliant on December 15, ⊙ = 327°.

The next good view fell on December 21, ⊙ = 330°. The surface-cap observed since April was now gone; and in its place there existed a larger, diffuse, and faint cloud-cap. During the first six months of 1942 this cloud-cap continued to be seen. Its brightness varied, but it was usually only moderately bright and seldom brilliant. Its size also varied. These fluctuations in size and brightness were apparently capricious. In addition to these variations there was a distinct trend toward increasing size as the season advanced. The evidence is strong that the increase between the minimum diameter and the diameter when observations ceased consisted of three rather sudden increments, each of about 10

degrees: the first between ☉ 327° and ☉ 330°, the second between ☉ 11° and ☉ 14°, and the third between ☉ 20° and ☉ 23° (Fig. 7). Usually no dark polar band surrounded the reviving cap between ☉ 330° and ☉ 59°. When occasionally recorded, this band was thin and light.

Two observations late in the southern summer under unusually good conditions deserve mention. Cave on December 28 at ☉ 334° and I on February 11, 1942, at ☉ 357° saw a minute and brilliant centre to a larger and relatively dull cap. It is certainly tempting to suppose that a remnant of the surface-cap was visible through overlying mists. Lowell has made a similar observation on the north cap.[7]

The North Cap

The north cap's visibility during most of the 1941-2 apparition suffered from the large negative value of D ⊕ (Table II). The variations in size are represented on figure 7. The curve is based upon measures of 63 *original* drawings by four observers between ☉ 168° and ☉ 59° but chiefly after ☉ 292°. This curve was prepared in the same way as the one for the south cap. Photographs, which fall between ☉ 261° and ☉ 296°, show no north cap.

I suspected a cap on December 25, 1940, at ☉ 121°; and H. Johnson recorded a small whitish spot surrounded by a darkish band at ☉ 126°. By ☉ 150° the north cap had practically disappeared, at least partly because D ⊕ was rapidly becoming more negative (Table II).

Between ☉ 155° and ☉ 290° usually no cap was seen. This evidence does not preclude the possible existence of a fairly large one; for example, when D ⊕ equalled − 20° a cap fully 40 degrees in diameter could not have been observed. Moreover, a north cap was intermittently visible, perhaps especially between ☉ 215° and ☉ 235°; when seen, it was usually small, faint, and diffuse. The bounding polar band was largely or wholly absent. Vaughn on June 22 with central meridian 313° drew a "gigantic" north cap and described it as almost equal in brightness to the south cap—perhaps a very transient appearance. R. Johnson on September 10 with central meridian 222° observed a small fairly bright area within a duller surrounding bright area, an aspect similar to what

Cave and I each once saw in the south cap. It appears clear that the north cap was a cloud-cap between ⊙ 155° and ⊙ 290°.

On October 17 at ⊙ 293° a whiteness near the north cusp gave me the impression that the cap was enlarging and reappearing from around the north limb. Records by Vaughn, Cyrus, Cave, and R. Johnson confirm an increase in size near this time. During the next several months the revived north cap gradually became, with apparently irregular variations, sharper and brighter, though at most only moderately bright. The diameter also varied but showed a definite increase between ⊙ 345° and ⊙ 5°, much as did the diameter of the south cap at the opposite season (figure 7). A probably variable bordering dark band was first surely seen at ⊙ 338°.

The cap first impressed me as a surface-cap on March 12, 1942, at ⊙ 11°. At ⊙ 20° it was large, pure white, and brilliant; and it subsequently usually showed these attributes. The bordering dark band also gained in strength and was comparable to the *maria* in conspicuousness after ⊙ 45°. By analogy with the south cap the spring melting should have begun near ⊙ 15°, but there is no evidence of a decrease in size as late as ⊙ 59°. It is possible, however, that the cap did diminish after ⊙ 15° but that this fact was concealed by an *apparent* increase due to both the increasing positive value of D ⊕ and the diminishing phase.

Colors on Mars

I did regular color-work between ⊙ 218° and ⊙ 268°, and several other observers made notes on colors.

The various tropical *maria* were all about the same hue. Near ⊙ 190° in May they showed only grays. By ⊙ 220° in June they were greenish blue; but any change must remain uncertain, for colors perhaps became easier to see as the planet approached. My observations show a loss of blueness near ⊙ 250°. The work of other observers neither contradicts nor confirms diminished blueness after ⊙ 250°; it merely shows blue still present from ⊙ 260° to ⊙ 295°. Some observers commented on the vagueness of Martian colors at this apparition.

The deep blue in Euxinus recorded in 1937 and 1939[4] was often vainly looked for. It was seen only on September 2 and 7, ⊙ = 265°

and 268° respectively, and had been absent as late as August 29. Even on the two dates mentioned the blue was less intense than at its maxima in 1937 and 1939; perhaps it is a seasonal phenomenon less notable after ☉ 215°.

The south cap was always white from ☉ 218° to ☉ 265°, the intensity of the color varying in an apparently unsystematic manner.

The south polar band appeared distinctly dark blue to Vaughn at ☉ 197°. H. Johnson saw only black in June and July. Between ☉ 235° and ☉ 262° I found a brown hue of rapidly variable strength. Whether the color altered as the season advanced, a view favored by the bluish gray seen between ☉ 180° and ☉ 230° in 1939,[4] is uncertain.

Cloud—Projections

Bright areas of greatly varying size and brightness projecting on the terminator were seen frequently, probably because they were attentively looked for and because the pronounced phase during June and July favored their visibility. The latter reason can also explain their rarity on the limb, where they had to be seen in profile. These projections of Table IV were *delicate* objects, and irradiation may have vitiated some data given there. The positions are approximate. The stated durations of visibility depended upon the longitudinal extents of the clouds. Almost all projections were seen in the sunset region rather than the sunrise region.

In 1922 Pickering observed projections ranging from $\beta + 45°$ to $\beta + 80°$ between ☉ 178° and ☉ 211°.[10] In 1939 our group observed 13 projections, average $\beta = +27°$, between ☉ 199° and ☉ 233°.[4] In 1941 we recorded 21 projections, average $\beta = -4°$, between ☉ 219° and ☉ 326°, mostly before ☉ 265°. There is an apparent southward motion of the projections as the northern autumn advances, and this circumstance suggests that projections are seasonal phenomena. At the three apparitions mentioned they have been largely either polar or equatorial objects, avoiding middle latitudes.

There is available a formula for computing the height of a projecting cloud on the terminator at a stated time if its position and angular breadth are known.[11] For these Martian clouds the angular breadths are not known so that only approximative

TABLE IV.

PROJECTIONS IN 1941

Date	Observer	λ	β	Duration	Remarks
June 21	Haas	244°	+14°	*about* 20 min.	Not recovered June 22
June 30	H. Johnson	188	−10		
July 2	Haas	126	−11		
July 10	Haas	65	+14	brief	Very small
July 22[a]	Haas	291	+15	10 to 20 min.	
July 23	Haas	282	+15		Minute and uncertain
July 23[a]	Haas	293	+15	a few min.	
July 24[a]	Haas	296	+10	a few min.	
July 25[a]	Haas	301	+20	a few min.	Extremely tiny
Aug. 1[b]	Haas	199	−10	a few min.	White area near same position on Aug. 2 did not project
Aug. 5[b]	Haas	188	+ 5		Not recovered Aug. 6
Aug. 17	Haas	35	0	10 min. or less	Extended through 10 degrees of lat.
Aug. 28[c]	Haas	311	+15		
Aug. 29[c]	Haas	298	+10		
Sept. 1[d]	Vaughn	134	−72		Lay near south cap
Sept. 2[d]	Vaughn	130	−72		Lay near south cap
Sept. 2	Vaughn	250	−57		
Sept. 22	Vaughn	≦42 to ≧61	+40	at least 80 min.	*About* five degrees farther south near λ61° than near λ42°
Oct. 20	Vaughn	104	+ 7		
Nov. 17*	Vaughn	350	−24		
Dec. 13	Barcroft	100	−10		Not seen by Haas Dec. 15

[a]These marks are very probably all identical. If so, the cloud had an average drift in increasing longitude of about five miles an hour over a three-day period. From July 22 to 25 the rate accelerated, and the cloud became lower.

[b]These clouds are *perhaps* identical.

[c]These clouds are *perhaps* identical.

[d]Since the angular radius of the south cap on these dates was about seven degrees (Table II, Figure 7), this cloud lay about 400 miles from the edge of the shrinking cap.

*Shown on figure 6 on Plate IX.

heights can be deduced; if we assume, compatibly with some experiments on artificial discs,[12] these breadths to be O″.5, we obtain heights of 10 to 15 miles for several typical July and August clouds.

I wish to thank Messrs. J. L. Divvens and L. Braymer for aid in preparing the plates.

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[11]H. M. Johnson and W. H. Haas, "Observations of Venus, 1938-42, and Their Interpretation," J.R.A.S.C., v. *37*, pp. 145-152 and 193-204, 1943.

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Note added in proof:—The author will supply at a nominal charge, photographic copies of the original drawing from which Plate VIII was made. Such photographs show somewhat more detail than does the plate.

New Waterford, Ohio,
January 11, 1945.

THE TWO ASPECTS OF SCIENCE

By Alfred Stiernotte

I WONDER if any of you have ever gone to the Astrophysical Observatory in Victoria. This observatory, as you know, is one of many observatories in which astronomers examine the heavens, carry on research as to the position, speed, and nature of the heavenly bodies. They are centres of that eternal finger of science pointing ever to the infinite depths of space, and giving us more and more visions of the immensity of the cosmos.

I am personally greatly fascinated by this science of astronomy. I recall that in the year 1936 I went to Victoria for the express purpose of visiting the observatory. I had been reading for many years the books on the heavens written by the charming pen of Camille Flammarion, and I may say he was my first scientific saint. Through the reading of his books, I caught something of the fire of his spirit and was urged, as all his disciples undoubtedly were to know something of the beauty, the wonder, and the immensity and the glory of the universe.

I had read a good deal about telescopes, these remarkable instruments penetrating to the depths of space to bring us records of far distant stars and galaxies. To me a telescope was almost a miraculous instrument, far more wonderful than the healing waters of Lourdes which burst forth from the song of Bernadette! So, I had wished for many years to actually see a large telescope, and in 1936 that wish was realized for I went to the Victoria Observatory and saw "with my own eyes" this large telescope, seventy-three inches in diameter, and forty feet long, so precisely poised and balanced it could be moved easily in every direction and point to any part of the skies. The telescope is protected by a spherical roof, but there is an opening in that roof, and through this opening you can see the heavens and the twinkling stars in it. And as I gazed in wonder at this telescope, and as I saw an astronomer sitting at one end, and making observations through it, I began to think along these trends of reflection: By means of this telescope the vision of the astronomer will penetrate beyond the clouds of the earth, beyond the planets, beyond the solar system, beyond the nearest stars, even beyond our universe to distant universes

mysteriously spending their throbbing lives on the confines of space! And when you weigh these tremendous facts quietly and reflectively, when you ponder on these truths discovered by astronomy, and by no other science, there comes upon you a sense of the immensity, the greatness and the wonder of the universe.

The cold and objective facts revealed by astronomy become thrilling facts, giving us the poetry of the universe and the song of the infinite. Just think of this immensity for a moment! The peculiar virtue of the science of astronomy is that it gives us precise conceptions of this immensity. For instance, the sun is a mere ninety-two million miles away from us; ninety-two million miles, quite a long ways off, but still close enough to make us complain of the heat in summer. The sun is surrounded by a family of nine major planets: Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus, Nepture, and Pluto, and over a thousand smaller planets.

Suppose we take a journey through space and we leave the solar system. We meet nothing on our way until we reach the star closest to the sun. This star is Alpha Centauri, and though it is the closest star, it lies at the distance of twenty-five trillions of miles away—mind you, not millions, or billions, but trillions of miles away! The light coming from this star travelling of course with the speed of light, which is one hundred and eighty-six thousand miles per second, takes actually four years to reach us. Now, if we go on with our journey through space, we pass star after star, each as large or larger than the sun until we reach the confines of our galaxy. Now, what we call our galaxy is simply the vast conglomeration of stars in which we belong. It is a vast conglomeration of about thirty billion stars arranged roughly in the shape of a watch. These billions of stars are in a flat circular arrangement, a little bulging at the centre, and are slowly revolving around a central axis. The diameter of this circular arrangement is approximately one hundred thousand light years. The light year, as you know, is the yardstick used by astronomers to measure space. It simply means the distance travelled by light in one year, that is six trillions of miles. So now, the diameter of this enormous galaxy of stars of which our sun is one is one hundred thousand times six trillions of miles. When you go home, just put those two numbers on paper and see what they look like.

Is this all there is to the heavens? Have we reached the end of space when we have travelled that far? By no means, for beyond our galaxy, or our universe, there are other universes, millions of them, possibly without limit. There is now being constructed at Mount Wilson, a telescope with a diameter of two hundred inches, the largest in the world, and the astronomer who will look through this telescope will be able to see a galaxy at the greatest distance ever perceived by man, that distance being one thousand million light years, that is one thousand million times six trillions of miles. That is how large the whole universe is, as far as we know, and it goes on without saying that such huge numbers, which are even greater than our income tax figures and our national debt, are utterly beyond our comprehension.

This is the immensity of the heavens as revealed by the science of astronomy, and by no other science.

And I can very well imagine that some sceptic might say: "That is all very well, but what good is it to me to know all these facts, all these stupendous numbers. Will that knowledge make my life easier? Will it bring a single dollar to my pocket book?" No, my friends, it will not bring you a single dollar, for astronomy is not a mercenary science. But we would be very wrong indeed to imagine that it is without value for our minds and spirits.

Men of all ages have been strangely fascinated by the tremendous and mysterious pageant of the heavens, by these remarkable constellations, by these brilliant stars, each of them a sun, by these incomprehensible distances, and they have wondered about the meaning of it all, and what man's place is in nature. As the old psalmist wrote:

> When I consider thy heavens, the work of thy fingers,
> The moon and the stars, which thou hast ordained:
> What is man, that thou art mindful of him?
> And the son of man, that thou visitest him?

And we still wonder, what is man, and what is his place in the vast scheme of things where he is lost in the immensity of space, living as he does on a small speck of dust we call the earth. Before this immensity we feel very small indeed, little mites who dare to probe the infinite. And yet, perhaps this is man's chief glory,

that he will not rest content with the rank of a mite, that he will go onward and onward, and try to unravel something of the Great Mystery. Edna St. Vincent Millay, in her poem "Renascence" is moved by the thought that she has actually unravelled this mystery:

> The sky, I thought, is not so grand;
> I 'most could touch it with my hand!
> And reaching up my hand to try,
> I screamed to feel it touch the sky.
> I screamed, and—lo!—Infinity
> Came down and settled over me;
> Forced back my scream into my chest,
> Bent back my arm upon my breast,
> And, pressing of the Undefined
> The definition on my mind,
> Held up before my eyes a glass
> Through which my shrinking sight did pass
> Until it seemed I must behold
> Immensity made manifold;
> Whispered to me a word whose sound
> Deafened the air for worlds around,
> And brought unmuffled to my ears
> The gossiping of friendly spheres,
> The creaking of the tented sky,
> The ticking of Eternity.
> I saw and heard and knew at last
> The How and Why of all things past,
> And present, and forevermore.
> The Universe, cleft to the core,
> Lay open to my probing sense. . .

Yes, we would like to have the "Universe cleft to the core" and "open to" our "probing sense." But it is far better that we do not know the answer, that we take fresh delight in gazing upon the order, the laws, the harmony, and the immensity of the universe, and continually feel the strange fascination of trying to grasp the meaning of it all. There is beauty in it, there is joy and there is glory, and this joy has been given by Keats:

> Then felt I like some watcher of the skies
> When a new planet swims into his ken;
> Or like stout Cortez when with eagle eyes
> He stared at the Pacific—and all his men
> Looked at each other with a wild surmise—
> Silent, upon a peak in Darien.

The watchers of the skies, our astronomers, must gaze at the heavens with a wild surmise, with an ever increasing fascination to know more about the mystery of it all.

This is, then, one aspect of science, that is pure science, the endeavors of scientists to know more about the laws of the universe, to know more about man's place in nature, about the infinitely large and the infinitely small. Any field of science can show this same delight in research, this sheer intellectual delight in knowing more of the nature of things. The chemist and the physicist wish to know more about the nature of the atom and the electron; and we have atom-smashers who are designed for no other purpose than to enable us to know more of the intricate mechanism of the "innards" of an atom! The biochemist is occupied to investigate the complex molecules, such as the protein molecule, which are tied up in the cells of every living thing, and which might well contain the secret of life.

The naturalist is occupied in classifying the many forms of ancient and modern life, of finding more and more remains of ancient forms of life, so that he may put a few more lines and a few more colors to his picture of evolution.

In all of these cases we find the same thing: the activity of men of science in its pure aspect, the aspect of pure discovery, of the advancement of knowledge for its own sake, of the fascination which the mysterious structure of the cosmos and life has for our intelligences. It is the sheer intellectual joy of the man of science, to be glorified by this endless quest:

> Yet all experience is an arch wherethrough
> Gleams that untravelled world whose margin fades
> For ever and for ever when I move.

This is where science takes on the aspect of art, the aspect of beauty, when it becomes almost a religion. When the scientist is moved by the advance of knowledge from the known to the unknown, when he for the first time lifts the veil of the unknown and reveals a new fact or a new theory giving us more understanding of the order and beauty of Nature, he cannot help but be urged on by the Eternal Mystery. And in so far as he finds a sense of glory in trying to reach, in trying to grasp the ineffable mystery, he is

religious. Someone has well said: "The undevout astronomer is mad." This is how science leads to religion, the constant striving of the mind of man for some sublime Truth that forever remains beyond his grasp.

In so far as the man of science does this, he is religious. In so far as an artist portrays forms of beauty, and these forms of beauty point to a beauty which he has not yet found, or uttered, but only dimly perceives he is religious. In so far as a reformer imagines forms of brotherhood and justice which he only as yet dimly perceives, but which he knows in his heart of hearts will mean a more abundant life for his fellow-men, he is religious. And, therefore, in so far as the man of science is attracted by the pure joy of assimilating more and more the harmony and the glory of the cosmos he is religious. For religion is the constant pull of ideal values in science, art, and ethics, to draw men beyond their present achievements.

That is one aspect of science, that aspect which some regard as useless—and yet in the highest sense useful, that aspect which brings it into the domain of art and religion.

The other aspect of science is, of course, the practical aspect, and the pure and the practical aspects are closely connected. They are both part of the advancing front of knowledge.

The astronomer may investigate the nature of stars—and he alone knows their nature; but he also gives valuable information for our ships at sea. The biochemist may investigate the workings of the human body, but he also produces such remedies as penicillin for the treatment of our soldiers. The metallurgist may investigate the structure of metals, but he also gives us stronger alloys for our machinery, for our bridges, and for our many forms of transportation. The chemist may study the structure of atoms and molecules, but he also gives us a whole variety of paints and varnishes and chemical dyes, and plastics to beautify our homes. Out of pure science flows applied science, and out of the funds provided for research in pure science will come the discoveries of applied science, and then their application to our everyday needs.

It is a commonplace to say that our modern age has been transformed by the applications of science. One needs only to think of modern means of transportation and communication, of radio and

television, of the many medical cures for dreadful diseases, in order to become aware of the large benefits which science conveys to us. It is so easy for people to think of science as materialistic, but they would be the first to fly into a blind rage if they could not get immediately the benefits of this so-called materialistic science!

And the housewife knows this best of all, with her modern electrically driven washing machines, electric ranges, and the regulated ovens, so that she can leave the roast in the oven, come to church, and then go home from church and find the roast cooked to perfection! And we think of the homes of the future where the air will be conditioned for moisture and temperature, where large windows with a new type of glass will admit all of the rays of the sun. A weekly paper in Vancouver in an article entitled "Houses of Tomorrow" paints a very appealing picture of the future homes:

> The water-pipes of the future will be unfreezable and the plumbing, like the Victorian child, ornamental, but never heard. Men do not need to worry about Satan finding occupations for the hands of their wives. There will be plenty to do, but on a more civilized and interesting plane. . . . No housewife wants to express her individuality in leaky waterpipes. But art and architectural crafts can be applied to designs and produced for the satisfaction of individual human tastes. A social policy for housing, planned by scientific means and democratically administered, will bring us to a new era and enlightened family and community living.

This then is the picture of applied science, the boons which applied science can give under a proper leadership. How soon these new homes will be available is difficult to say. The picture is a little unrealistic in view of the Vancouver housing situation. But nevertheless they are within the reach of our children if we plan for them.

These are, then, the two aspects of science, pure science, which in its quest for the beauty and harmony of the forms of Nature, is related to art and religion. And applied science whose purpose is to make the life of man more abundant, and free from drudgery, and free to be spent on the higher things of the spirit. It also is thereby religious.

First Unitarian Church,
Vancouver, B.C.

REVIEW OF PUBLICATIONS

Five-Figure Logarithm Tables. By H.M. Stationery Office, compiled by E. Chappell. 6 x 9½ ins. 120 pages, 1944. Price 7s 6d net.

These tables consist of three parts: first, the logarithms of the natural numbers from 10,000-40,000 and 4,000 to 10,000; second, the logarithms of the sine and tangents of angles from 0°-5° for each thousandth of a degree and the cosines and cotangents from 85°-90° with the same intervals; third, the logarithms of the trigonometrical functions from 0°-90° given to each hundredth of a degree.

They are the most convenient tables published when computing in fractions of a degree. For the natural numbers no interpolation is necessary to get 5-place accuracy in the first part of the table and the interpolation in the second part is very easy. Also the inclusion of the first five degrees given to the thousandth of a degree in the logarithm of the trigonometrical functions reduces the interpolation here.

The tables are nicely bound and very reasonably priced.

R.K.Y.

Practical Marine Navigation, by James A. Stowell. 7 x 10 ins., 133 + viii pages, 1945. Boston, Mass., Addison-Wesley Press Inc. Price $2.50.

This little book is added to the recent flood of American books on navigation because the author's experience in teaching the subject to boys of high school age led him to the opinion that most books are too complicated in wording and development. Roughly half the book deals with compasses and sailings, and the second half with nautical astronomy.

Only classical methods are included, despite the simplicity of concept of some of the shorter methods. Much space is devoted to worked examples, which are useful computational guides.

It is startling to read a book which deals so much with astro-navigation and search in vain for any discussion of sextants; the index, incidentally, is a table of contents rather than a conventional index. The book is well bound, but the price seems unusually high for this small lithographed volume. F.S.H.

Nicholas Copernicus—A Tribute of Nations, edited by Stephen P. Mizwa, A.M., LL.D. Pages xix, 268, 6¾ x 10 in., 69 illustrations. N.Y.: The Kosciuszko Foundation, 1945. Price $5.00.

This handsome volume gives an account of the celebration of the four-hundredth anniversary of the death of Copernicus and the publication of his book, *De Revolutionibus Orbium Coelestium*. Copernicus died on May 24, 1543, and it is reported that on his deathbed the first printed copy of his great work was placed in his hands.

The ruthless and barbarous manner in which the Polish nation has been treated in the present war caused the flight of many of its leaders in politics and education to other countries, especially to Great Britain and North America. To the latter many Poles had migrated in past years, and when the proposal to celebrate the quadricentennial of the death of Copernicus was made it obtained an interested and sympathetic reception. The Kosciuszko Foundation (organized in 1925) undertook the task of carrying out this great work, and its active and capable secretary, Dr. Stephen P. Mizwa, prepared an attractive booklet giving information about Copernicus and also useful suggestions for programmes in his honour. The celebration was an enormous success, not just on the American continent but in other countries as well.

Part One of the volume outlines the tribute of the United States; Part Two, that of other nations; at the end are full indexes of names, institutions, organizations and published articles. The numerous illustrations are in collotype and are well printed.

The first fifty pages contain a full report of the imposing National Celebration held in Carnegie Hall in New York on May 24, 1943. The chairman was Dr. Harlow Shapley, who read a message from President Roosevelt, which was followed by a message from the President of the Republic of Poland. After this there was (1) an exchange of greetings by radio between American and British scholars; (2) a learned address by Dr. Oscar Halecki on "The Polish Golden Age in the Era of Copernicus"; (3) an illuminating paper on "Nicholas Copernicus, the Founder of Modern Astronomy" by Dr. Edward Rosen, who was described by the chairman as "the leading Copernicus scholar in America." These contributions are printed in full. Then there was presented "A Copernicus Citation" to each of

ten "modern revolutionaries" selected by a special committee. Among these ten were: Walter E. Disney, Albert Einstein, Henry Ford, and Orville Wright—all certainly well known to the world. The programme was varied by music on the violin and the harpsichord, mostly composed and played by Polish musicians.

Messages of tribute from a large number of outstanding institutions and distinguished men occupy thirty-one pages.

The list of commemorative programmes presented in colleges and universities, by learned societies, in planetariums, over the radio, and by citizens' committees; together with tributes of the political world and extracts from printed articles, make a splendid exhibit.

Besides the already mentioned papers and addresses printed in full, the volume contains the lecture by Dr. Roy K. Marshall on the "Music of the Spheres" at the meeting at the Fels Planetarium; the dramatization of the most important episodes in the life of Copernicus presented over Station WSUI, State University of Iowa, the script for which was prepared by Dr. C. C. Wylie, Professor of Astronomy, and Dr. Marcus Bach, Department of Religion; the address by Dorothy Thompson on "Copernicus as Citizen, Statesman and Soldier" over Station WJZ, New York. In the latter the speaker presented (for the first time in English) the translation of a letter discovered in Sweden in 1908 which was written in 1516 by Copernicus to the King of Poland complaining of the assaults and robberies perpetrated by the Teutonic Knights. History repeated itself in Poland in the present war! The letter is reproduced in facsimile, which gives a certain reality to the appeal for help.

The book presents a worthy record of tributes paid to Copernicus.

C.A.C.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Request for February Journals

Owing to an unusually large circulation of the February 1945 *Journal*, the Society's normal reserve supply is seriously depleted. The officers of the Society would greatly appreciate it if forty or fifty of the members who do not save complete files of their *Journals* would mail their copies of the February *Journal* back to the General Secretary (198 College St., Toronto 5).

During the past six years mail service to progressively more and more of our large number of overseas subscribers has been discontinued. We expect that shortly after the cessation of hostilities many European institutions will wish to complete their long sets of our publications. Thus each month we have set aside a number of *Journals* to replace these suspended subscriptions and to aid in re-establishing libraries destroyed by war. It is to complete our reserve for this purpose that we ask the co-operation of members in sending us February *Journals*.

F. S. H.

Accommodation in Saskatchewan for Eclipse Observers

Mr. Cyril Hallam, of our new and very active Windsor Centre, has been making enquiries as to securing living accommodation along the eclipse path in July. We are pleased to quote the following information from Wolseley, Saskatchewan.

> The Mayor is most anxious that the citizens of the town should do all possible to welcome and accommodate visitors. We have one hotel, a very comfortable one, but we think it may be insufficient to accommodate the number who may be in the town as observers of the eclipse of the week-end of the 9th of July. We are at a loss to know how to make the fact known that we are desirous of arranging all possible accommodation for visitors. Private homes can certainly be made available. Perhaps you are in touch with a source through which our desire could be made known. I should suggest that if you are, that you should ask persons intending to come to Wolseley on the week-end of the eclipse to send their requests for accommodation to the Mayor of Wolseley, Sask.

F. S. H.

Calculation of Absolute Magnitude

Absolute Magnitude is the apparent magnitude which a star would have at a distance of 32.6 light years or with a parallax of .1".

If the visual magnitude of a star and its parallax are known, we may calculate the absolute magnitude by the formula:

$$m + 5 + 5 \operatorname{Log} \pi = \text{Absolute Magnitude}$$

where m is the visual magnitude and π is the parallax.

The values worked out from this formula may be tabulated and used for ready reference, saving repeated calculations. Such a table follows:

Dist. in Lt. Yrs.	*Parallax*	*Code*	*Dist. in Lt. Yrs.*	*Parallax*	*Code*
4	.812	4.6	80	.041	—2.0
6	.544	3.7	90	.036	—2.2
8	.408	3.0	100	.032	—2.4
10	.326	2.5	125	.026	—2.9
12	.272	2.2	150	.022	—3.3
14	.233	1.8	170	.019	—3.6
16	.204	1.4	200	.016	—3.9
23	.142	.9	250	.013	—4.4
27	.121	.4	300	.011	—4.8
33	.100	0	360	.009	—5.2
39	.084	— .4	400	.008	—5.5
45	.073	— .7	470	.007	—5.7
50	.066	— .9	540	.006	—6.1
55	.060	—1.1	650	.005	—6.5
60	.053	—1.4	800	.004	—7.0
70	.047	—1.7	1100	.003	—7.6

Find the code for your star, according to its parallax or distance, from this table, and add it to the visual magnitude of said star. The answer will be the absolute magnitude. For example:

Procyon is 10 light years away and its visual magnitude is .5. From the table we find the code for 10 LY is 2.5. Then 2.5 + .5 = 3.0, which is the abs. mag. of Procyon.

Rigel has a parallax of .006. Its vis. mag. is .3. From the table we find the code for .006 is —6.1. Add —6.1 and .3 and we have —5.8 which is the abs. mag. of Rigel.

This chart is abbreviated, but values for figures in between those given above can be closely estimated by using the nearest figures given.

W. N. Barnholth

Akron, Ohio.

MEETINGS OF THE SOCIETY

AT EDMONTON

November 9, 1944—The President called the meeting to order at 8.18 p.m.

The minutes of the previous meeting were read and approved.

Business arising: Mr. Wates moved that the Collier Lunar Photos be provided with a suitable container in the Observatory; that a key map be provided; and that the treasurer be authorized to spend up to ten dollars for these purposes. The map, which had been mounted by Dr. Rutherford, was shown to the audience.

New business: The President announced the nominating committee as Dr. Campbell, Mr. Stockwell, and Mr. MacAulay.

An application for membership from Mr. T. M. Carscadden was received, nominated by Dr. Gowan and Dr. Campbell. The usual motion of acceptance was made by Mr. Deane and Mr. Blue, and carried.

The Librarian announced the acquisition of two new books.

Mr. Montgomery was appointed auditor for this year.

Mr. Wates gave the Handbook talk. The main interest is in the planets:—Venus in the western sky during early evening; Jupiter and Saturn are visible in the morning sky. We should remember that conjunction of two heavenly bodies means that they have the same right ascension, but not necessarily the same declination.

The main paper was given by Dr. E. H. Gowan on the subject, "Telescope Faults."

The main aberrations of lenses and mirrors were discussed, and where possible illustrated by experiment. Spherical aberration, astigmatism, chromatic aberration, field curvature, distortion, and coma were included.

Special methods and gadgets for correcting these were outlined, including the achromatic lens, the use of aplanatic points, the Mangin mirror, paraboloidal surfaces, the Maksutov meniscus, and the Schmidt refracting plate. The last two make possible the use of spherical reflecting surfaces. Most of these were illustrated by diagrams, since none of the actual apparatus has been made here yet.

The meeting adjourned for refreshments at 10 o'clock. There were 29 members and visitors present.

E. H. GOWAN, *Honorary Secretary.*

AT VANCOUVER

October 10, 1944.—The first meeting of the 1944 session was held in the Science Building at the University of British Columbia.

The speaker at this opening meeting was Dr. H. D. Smith of the Physics Department and his subject, "The Time Scale of the Universe." The subject is timely due to recent work by Chandrasekhar and Miss Tuberg. Dr. Smith pre-

sented the chief evidence for the age of the earth, that is a study of the radioactive series and the relative amounts of lead to earlier members of the series. However, a study of these data gives us a lower limit to the age of the universe, since the radioactive processes are active only after a solid earth is formed. The speaker discussed the mechanism of the formation of stars from the original primordial gas which spread throughout space. It is difficult to calculate the age of the universe from such a study, since our data regarding initial conditions in the diffuse matter is somewhat meagre. A study of the dynamics of star clusters is more profitable, since we can observe the motions of individual stars and apply the laws of dynamics to calculate the time required for the clusters to reach their present state.

Most of the evidence indicates that the age of the universe is of the order of two or three billion years. Studies of radioactive elements in the earth's crust, production of energy by nuclear processes in the sun's interior, the dynamics of double star systems, open star clusters and groups of galaxies, the apparent rate of recession of the galaxies all combine to give the above time scale.

There is some evidence that a longer time scale is necessary. The present position of the sun along its energy cycle and certain work on groups of galaxies seems to demand a longer time for the age of the universe. More statistical work should be done when increased data is available on the distribution of galaxies in space.

At the conclusion of the lecture there was considerable discussion regarding pre-stellar conditions in the universe.

November 14, 1944.—The speaker at the November meeting was Mr. Walter J. Lind, a lighting engineer associated with the Canadian General Electric. Mr. Lind spoke on "The Magic of the Spectrum," and was interested mainly in giving the audience a review of the subject of ultra-violet, visible, and infra-red lamps.

The speaker first traced the improvements in the incandescent lamp. Edison's original lamp had an efficiency of only 0.5%, whereas modern tungsten lamps are 10% efficient. The fluorescent lamp has a still higher efficiency, around 20%. In this regard it is interesting to note that fireflies and certain forms of fluorescing sea life have an efficiency of 95%.

Mr. Lind went on to discuss the complete electromagnetic spectrum and explained the relative positions and extent of the ultra-violet, visible and infra-red regions. Ultra-violet lamps have many germicidal uses in hospitals and public health work and will be used to a far greater extent in the future.

Infra-red lamps have many industrial uses such as drying paints and lacquers. The lecture closed with a discussion of lamps of the future. During the evening Mr. Lind put on a number of excellent demonstrations of light sources and colours.

December 12, 1944.—The regular meeting of the society was held on December 12th at the Science Building of the University. The speaker at this last meeting of the year was Mr. R. E. G. Langton of the Physics Department. His topic, "Cosmic Rays," was a timely one in view of much recent experimental and theoretical work.

Mr. Langton first discussed the early experiments which led to the discovery and isolation of cosmic rays. Early work was concerned with studying the distribution of this radiation as a function of latitude and longitude, height above the earth's surface, and depth beneath the ocean surface. This study is continuing and the acquired data is useful to the theorists.

The speaker next discussed methods of detecting and observing cosmic rays. These can be counted by means of a "Geiger Counter," a special discharge tube in which the cosmic rays produce ionization. Since the cosmic rays affect photographic emulsions, they can actually be recorded by photographic means. It now appears that cosmic rays have a place in the family of atomic particles, and much of the present work is concerned with the interaction between these two.

To understand the origin of this extra-terrestrial radiation, a necessary step must be to calculate the energy associated with a cosmic ray. A lower limit to this quantity may be obtained by finding the energy a particle must have to penetrate the earth's magnetic field at different latitudes. The passage of a cosmic ray through the earth's atmosphere is a complicated phenomenon, and many "secondary" particles are produced by collision. A study of these secondary effects narrows the possible choice for the nature of the original cosmic rays. The evidence points to the fact that most of the original particles are protons and singly ionized helium atoms.

The speaker closed by briefly discussing the source of cosmic rays.

WILLIAM PETRIE, *Recorder.*

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(Continued at bottom of next page)

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA
1890-1945

The Society was incorporated in 1890 under the name of The Astronomical and Physical Society of Toronto, and assumed its present name in 1903.

For many years the Toronto organization existed alone, but now the Society is national in extent, having active Centres in Montreal and Quebec, P.Q.; Ottawa, Toronto, Hamilton, London and Windsor, Ontario; Winnipeg, Man.; Edmonton, Alta.; Vancouver and Victoria, B.C. As well as about 950 members of these Canadian Centres, there are over 200 members not attached to any Centre, mostly resident in other nations, while some 300 additional institutions or persons are on the regular mailing list for our publications.

The Society publishes a monthly "Journal" containing about 500 pages and a yearly "Observer's Handbook" of 80 pages. Single copies of the "Journal" or "Handbook" are 25 cents, postpaid. In quantities of 10 or more copies, the price is 20 cents a copy.

Membership is open to anyone interested in astronomy. Annual dues, $2.00; life membership, $25.00. Publications are sent free to all members or may be subscribed for separately. Applications for membership or publications may be made to the General Secretary, 198 College St., Toronto.

The Society has for Sale:

Reprinted from the "Journal" of the Royal Astronomical Society, 1936-1944.

The Physical State of the Upper Atmosphere, (revised 1941) by B. Haurwitz, 96 pages; Price 75 cents postpaid.

General Instruction for Meteor Observing, (revised 1940) by Peter M. Millman, 24 pages; Price 15 cents postpaid.

The Visual Photometry of Variable Stars, by H. Boyd Brydon, 64 pages; Price 50 cents postpaid.

A Yoke Mounting for the Six-inch Telescope, by H. Boyd Brydon, 8 pages; Price 10 cents postpaid.

Setting Up and Adjusting the Equatorial Reflecting Telescope, by H. Boyd Brydon, 25 pages; Price 25 cents postpaid.

Occultations: their Prediction, Observation and Reduction, by H. Boyd Brydon, 76 pages, 1944; Price 60 cents.

In quantities of ten or more copies, a discount of 20 per cent will be allowed. Send Money Order to 198 College St., Toronto.

(*Continued from previous page*)

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